Introduction to embryology

The survival of each species of virus, bacteria, fungi, plants and animals requires its individual members multiply to produce new individual to replace the one killed by natural death in old age or by predators, parasites, environmental pollution or any ecological hazards such hot,loss of water or food, oxygen, light, etc.

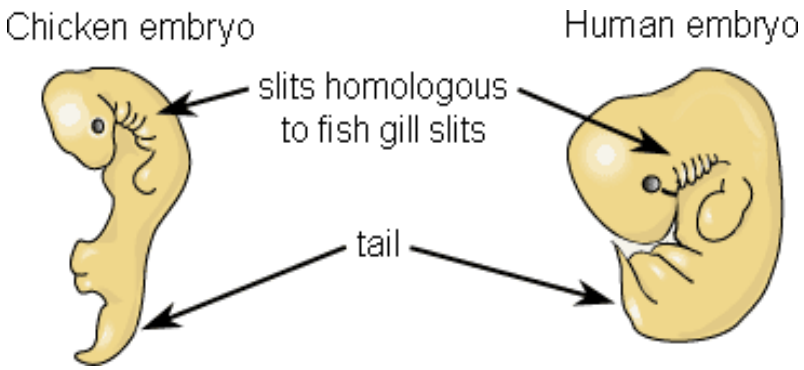
The multiplication of new species is achieved by two basic process, called asexual reproduction, and sexual reproduction

- **In the asexual reproduction**, the progeny arises from single existing organism which splits, buds or fragments from the body of the organism, to give rise to two or more offspring's, all of which have hereditary traits identical to those of the parental organisms.
- **In the sexual reproduction**, the progeny arises from the fusion of the two genetically identical gametes (sperms & eggs) in the multicellular animals; each of them is derived from different sex of the organisms with genome different from the parent, the resultant cell called **fertilized egg or zygote** has a genomic different from that of their parents.

The process which transform zygote or somebody rudiment of parent somatic cells (i.e; asexual and sexual reproduction respectively) into a multicellular organism constitute two different aspects of **Ontogenetic development** and phylogenetic development.

The ontogenetic development differ from the phylogenetic development, In biology, phylogenetic is the study of the evolutionary history and relationships among individuals or groups of organisms that are derived from a common ancestor, while the ontogenetic development of a species include developmental history of an organism means, embryogenesis, development of a new individual from the fertilized egg and then to blastogenesis or development of a new organism from a sexual reproduction body(bud, body fragments,etc.) . By studying ontogeny (the development of embryos), scientists can learn about the evolutionary history of organisms. Ancestral characters are often, but not always, preserved in an organism's development. For example, both chick and human embryos go through a stage where they have slits and arches in their necks that are identical to the gill slits

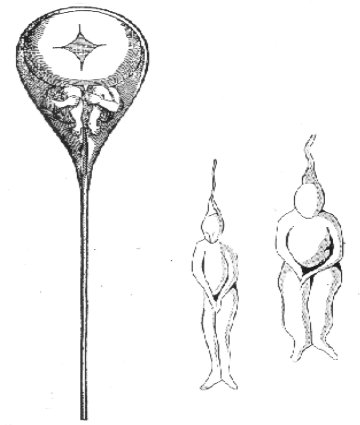
and gill arches of fish. This observation supports the idea that chicks and humans share a common ancestor with fish. Thus, developmental characters, along with other lines of evidence, can be used for constructing phylogenies.



Historical review of the embryology

pre-20th century, Embryology was not easily separated from Medicine, Anatomy and Physiology and other biological sciences. Embryology has a long history. Aristotle proposed the currently accepted theory of epigenesis, that organisms develop from seed or egg in a sequence of steps. The alternative theory, preformationism, that organisms develop from pre-existing miniature versions of themselves,

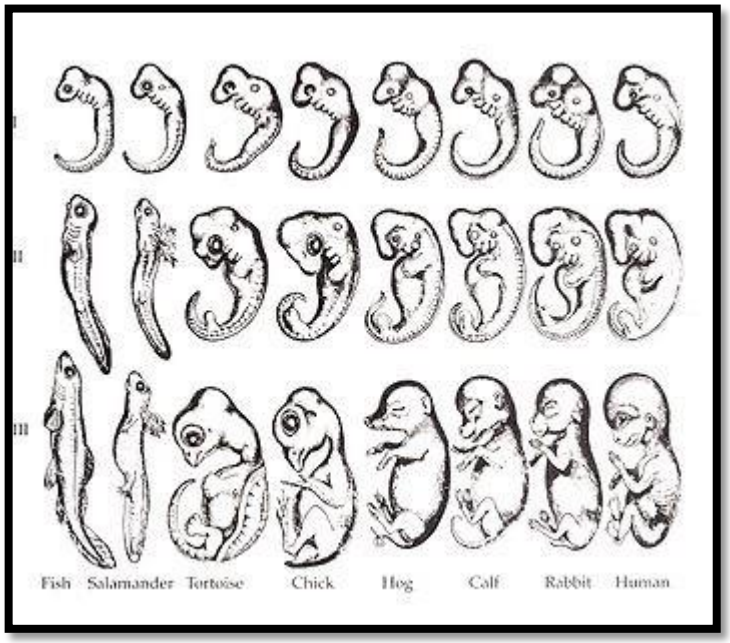
as the 18th century, the prevailing notion in western human embryology was preformation : the idea that semen contains an embryo – a preformed, miniature infant, or *homunculus* – that simply becomes larger during development, As microscopy improved during the 19th century, biologists could see that embryos took shape in a series of progressive steps, and epigenesis displaced preformation as the favored explanation among embryologists.



preformationism theory

Biogenetic law, also called **Recapitulation Theory**, postulation, by Ernst Haeckel in 1866, that ontogeny recapitulates phylogeny—*i.e.*, the development of the animal embryo and young traces the evolutionary development of the species. The theory was influential and much-popularized earlier but has been of little significance in elucidating either evolution or embryonic growth.

biogenetic law, in biology, a law stating that the earlier stages of embryos of species advanced in the evolutionary process, such as humans, resemble the embryos of ancestral species, such as fish. The law refers only to embryonic development and not to adult stages; as development proceeds, the embryos of different species become more and more dissimilar. An early form of the law was devised by the 19th-century Estonian zoologist von Baer, **who observed that embryos resemble the embryos, but not the adults, of other species**. A later, but incorrect, theory of the 19th-century German zoologist Ernst Heinrich Haeckel states that the embryonic development (ontogeny) of an animal recapitulates the evolutionary development of the animal's ancestors (phylogeny).



The development of an organism involves all changes it undergoes from its beginning until death, most metazoan animals include two distinct periods in their life history:

1- Embryonic period or called Pre-natal period

This represents the period in the egg or inside the body of the mother.

2-Postembryonic period or called Post-natal period

extend from hatching or birth up to the natural death of the organism due to aging. Thus all the developmental events and changes which occur from the time of fertilization of the egg through formation of the embryo or foetus up to hatching or birth belong to the pre-natal or embryonic period of the life history of the animal are included in embryogenesis, so the study of embryogenesis is called embryology. So we can define the embryology is: all the developmental events and changes which occur from the time of fertilization of the egg through formation of the embryo or fetus until the belong to the pre-natal or embryonic period

Embryological development does not end at birth but continuous during the post- natal period also. the newly born or hatched young animal is in size and developed both structurally and physiologically. During later days, weeks or years many changes occur lead the individual

capable of reproduction this period called (progressive nature), then after the animal reach to maximum of development this time called (degenerative in nature) leads to death.

In biology the field which deals with the study of those embryogenetic and blastogenetic process by which organism undergoes progressive changes in structure and function during its life history is called developmental biology.

In fact, developmental biology, unlike embryology because does not restricted to the study of the embryogenesis of the organism but deals with all aspects (genetic, biochemical, physiological and morphological).

Therefore the different in the concept between the embryogenesis and the development is that the development is a wider term than the embryogenesis,

Review of chordate embryogenesis stages

The embryogenesis of an animal species includes the following stages or phases:

1) Gametogenesis

This stage is started from the time of development and specialization of haploid male & female sex cells, from diploid somatic cells of each parent during a process called **Gametogenesis**. Gametogenesis includes **spermatogenesis** in male tests and **oogenesis** in female ovaries.

2) Fertilization

This second phase of embryogenesis is fertilization, which is the union of spermatozoon (sperm) and the ovum and then activation of egg to begin the embryogenesis of a new individual.

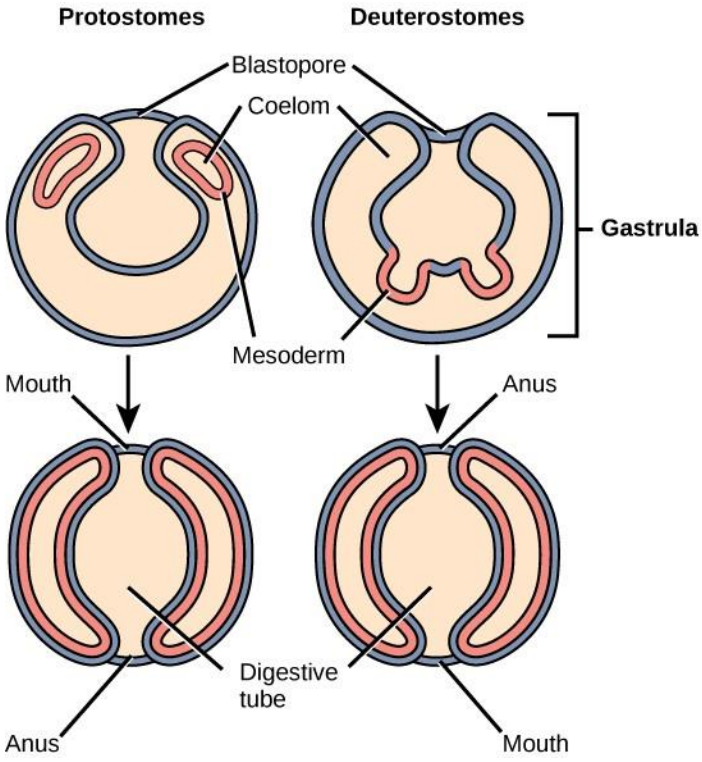
3) Cleavage

During third phase of embryogenesis, the cleavage, **no growth** of egg cytoplasm(ooplasm) occur, but rate of synthesis of some macromolecule such as DNA, protein, glycogen, fats and yolk, so the fertilized egg undergoes repeated mitotic cell divisions and produces a compact mass of cells (blastomeres), called **morula**. The morula soon get arranged in hollow spherical mass, called **blastula**, with a layer of **blastomeres** called blastoderm surrounding a fluid-filled central space or cavity, and called the **blastocoel**. The process of conversion of a fertilized egg into multicellular blastula called **blastulation**.

4) Gastrulation

In this phase, there are an extensive movements and rearrangements of cells of blastula, called (morphogenetic movements) transforming the one-layered thick embryo (blastula) into a two or three-layered thick embryo, called Gastrula. From the gastrula the **three primary germ layers** are formed, the outer layer called ectoderm, the middle layer called mesoderm, and the inner layer called endoderm; from these three germ layers various organs of animal body are formed. so they called primary germ layers

In the middle center of the gastrula found a central cavity called the **archenteron (gastrocoel)**, which is lined by endoderm and communicates to the outer environment by an opening called **blastopore**. During later stages of the development, the archenteron becomes the cavity of the alimentary canal, while the blastopore becomes **mouth opening in all invertebrates**, **except echinoderms and hemichordates**, these animals in embryology called **protostomia**. But in the other groups of animals includes echinoderms, hemichordates and all chordates the blastopore becomes the anal opening (anus)**,** therefore called **duterostomia**.(notice the figure below).



5) Organogenesis

During the fifth phase of embryogenesis, the organogenesis or named the formation of the organs. The continuous growing of the masses of the three germ layers will split up into smaller groups of cells, called primary organ rudiments, each of which is destined to produce a certain organ or part of the adult body. The primary organ rudiments further subdivided into secondary organ rudiments which are the rudiments of the simple organs, with the appearance of primary and secondary rudiments the embryo begins to show some similarity to the adult animal or larva if the development includes larval stage

6) Growth

The simplest definition of the growth in embryology is the **increase in the body mass of the animal**. This increase in the body mass is achieved by synthesis of new nuclear material and cytoplasm and cell multiplication, thus during growth period the organ rudiments of the embryo begin to grow and greatly increase their volume.

7) Differentiation

The differentiation refers to the events by which parts become different from one another and also different from their origin. During development differentiation includes following kinds:

a- Morphological differentiation

When the cells of the organ rudiments multiply, the individual cells and group of cells become structurally different from another (cytodifferentiation) e.g; the nerve cells and epidermal cells originate from a common starting point (ectoderm) later they acquire different feature of size, shape.

b- Behavioral (physiological) differentiation

All cells have common basic activity such as metabolism, synthesis of DNA,RNA, proteins, lipids, carbohydrates, etc. but after later development these cells acquire special function, nerve cells come to transport electric impulses, muscle cells to contract, gland cells to secret and so on.

c- Chemical differentiation

The cytodifferentiation and physiological differentiation are the products of chemical differentiation which in turn depends on enzymes which direct the synthesis of the organic compounds that give the specialty of the cells, this production of chemicals is under genetic control of the cell.

8) Morphogenesis

The morphogenesis refers to that tissues and organs are take a special shape and size that make the special form of the organism body. The **form** of an organism depends on two main factors:-

- the form of the cells (differentiation)
- the position of the different cells

the process of the morphogenesis depend on the communication between the growing cells physically and chemically .the embryonic cells capable to motile so that the same type of

cells become reassociated together. morphogenes are chemicals produced during development to determine the morphogenesis and differentiation of cells, tissues or organs.

The morphogenes are two types :

1- Intra-cellular morphogenes

Found within a oocyte determinate the fate of the early embryo found in insects, nematodes and tunicates

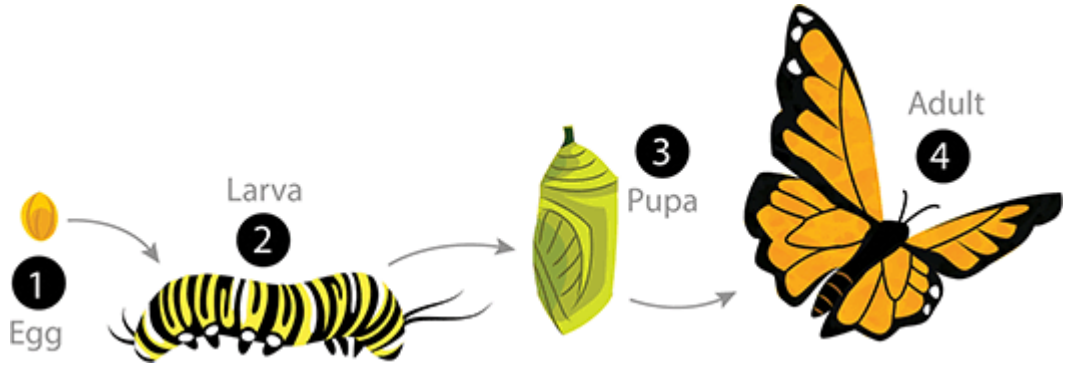
2- Extra-cellular morphogenes

Found in particular regions of late embryos, they acquire activity when the embryo has become multicellular (i.e; after 2-cell stage of egg)these are analogous chemicals to hormones, During development, retinoic acid, a metabolite of vitamin A, is used to stimulate the growth of the posterior end of the organism.[12] Retinoic acid binds to retinoic acid receptors that acts as transcription factors to regulate the expression of Hox genes (group of genes that regulate the body plane of the embryo along head—tail axis) Exposure of embryos to exogenous retinoids especially in the first trimester results in birth defects.

9) Metamorphosis

The growth, differentiation and morphogenesis transform the embryo into a young animal. After hatching from the egg morphological features are similar to the adult animal except in being of small and sexually immature, so this will called **juvenile stage** or not similar with adult animal because may found different types of organs which serve the young animal during certain period and disappear later, this is called **larval stage**. The young larva later passes through an important development process called the metamorphosis **means:**

morphological and physiological changes of the larva during normal development causes transforms it into an animal similar to the adult, the metamorphosis is regulated by hormones. Most invertebrates pass through metamorphosis during their life cycle, but some vertebrates, such as frogs, also go through this process before reaching adulthood



Branches of Embryology

1- Descriptive embryology

For centuries observation and descriptive of different embryonic stages of the ontogenetic development of a species depend on notices.

2- Comparative embryology

Comparative study is made between the embryology of most animals types.

3- **Experimental embryology**

This is youngest and most modern field in embryology, study the fertilization, cleavage, and gastrulation in the vivo.

4- Chemical embryology

Study the embryology phases in molecular terms